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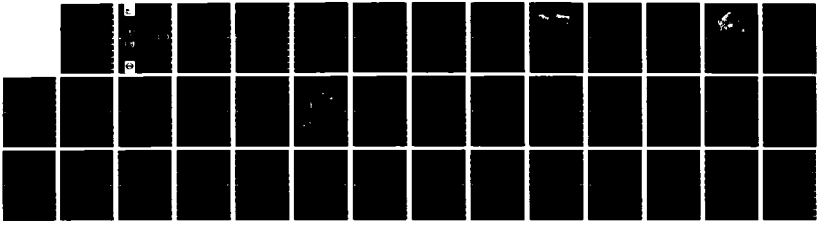

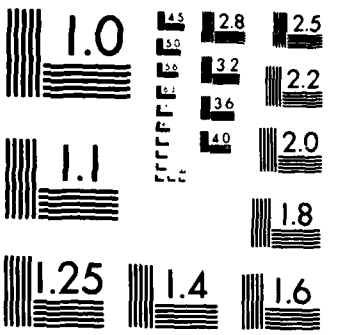
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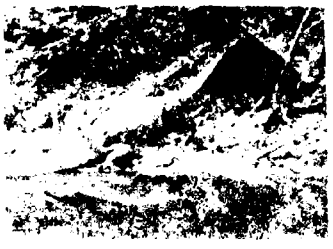

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OSPREY (*Pandion haliaetus*)

Section 4.3.1, US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL

by

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July 1986
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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A wildlife species account for the osprey (*Pandion haliaetus*) is provided as Section 4.3.1 of the US Army Corps of Engineers Wildlife Resources Management Manual. The account is developed as a guide to provide the biologist or resource manager with basic information on the biology, distribution, ecology, and management of the osprey. Major topics covered include status, characters and measurements, population attributes, distribution and abundance, habitat requirements, management, and census and sampling.

The status of the osprey in the United States is described, and the importance of the species as an environmental indicator is discussed. The section on population attributes includes details on breeding biology, migration, dispersal of young, mortality, and impact of pesticides. The present nesting population in the contiguous United States is estimated at approximately 8000 pairs. The status of nesting populations is described regionally for the Pacific Northwest, Western Interior, Great Lakes, Atlantic Coast, and Florida and the (Continued)

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19. ABSTRACT (Continued).

Gulf Coast. The ecological requirements of ospreys and their association with marine environments, rivers, lakes, and reservoirs are discussed. Management objectives and strategies are presented, and basic procedures for conducting population surveys are described.

PREFACE

This work was sponsored by the Office, Chief of Engineers (OCE), US Army, as part of the Environmental Impact Research Program (EIRP), Work Unit 31631, entitled Management of Corps Lands for Wildlife Resource Improvement. The Technical Monitors for the study were Dr. John Bushman and Mr. Earl Eiker, OCE, and Mr. Dave Mathis, Water Resources Support Center.

This report was prepared by Dr. Charles J. Henny, US Fish and Wildlife Service, Patuxent Wildlife Research Center, Pacific Northwest Field Station, Corvallis, Oreg., under an Interagency Agreement with the US Army Engineer Waterways Experiment Station (WES). Mr. Chester O. Martin, Team Leader, Wildlife Resources Team, Wetlands and Terrestrial Habitat Group (WTHG), Environmental Laboratory (EL), was principal investigator for the work unit. Although the majority of this report resulted from a literature review, unpublished population numbers and production rates were obtained from numerous individuals and agencies. The sources for the distribution, abundance, and production rate information were listed in an earlier report (Henny 1983) which summarized the data. The assistance of all who provided unpublished information is appreciated. S. N. Wiemeyer, US Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Md., improved the manuscript with his comments on an earlier draft.

The report was prepared under the general supervision of Dr. Hanley K. Smith, Chief, WTHG, EL; Dr. Conrad J. Kirby, Chief, Environmental Resources Division, EL; and Dr. John Harrison, Chief, EL. Dr. Roger Saucier, WES, was Program Manager, EIRP. The report was edited by Ms. Jessica S. Ruff of the WES Publications and Graphic Arts Division (PGAD). The osprey drawing was prepared by Mr. David R. (Randy) Kleinman, Scientific Illustrations Section, PGAD.

At the time of publication, COL Allen F. Grum, USA, was Director of WES, and Dr. Robert W. Whalin was Technical Director.

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NOTE TO READER

This report is designated as Section 4.3.1 in Chapter 4 -- WILDLIFE SPECIES ACCOUNTS, Part 4.3 -- RAPTORS, of the US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL. Each section of the manual is published as a separate Technical Report but is designed for use as a unit of the manual. For best retrieval, this report should be filed according to section number within Chapter 4.

OSPREY *(Pandion haliaetus)*

Section 4.3.1, US ARMY CORPS OF ENGINEERS
WILDLIFE RESOURCES MANAGEMENT MANUAL

The osprey (*Pandion haliaetus*) is a large, highly visible bird of prey that often lives in close association with man. In most situations, this is a harmonious association in which ospreys are considered to have a high aesthetic value and offer a special attraction to bird watchers and naturalists. The osprey is the only living representative of the genus *Pandion* and the subfamily Pandionidae and is extensively specialized for capturing fish, which constitute almost its entire diet. The species is almost cosmopolitan, though more rare in the Southern Hemisphere where it breeds with regularity only in Australia and adjacent islands (Brown and Amadon 1968). A generalized map of the worldwide distribution of ospreys is provided as Figure 1.

Vaurie (1965) and Brown and Amadon (1968) list 5 subspecies; more recently, Prevost (1983) lists the following 4 subspecies: *P. h. haliaetus, carolinensis, ridgwayi,* and *cristatus* corresponding, respectively, to

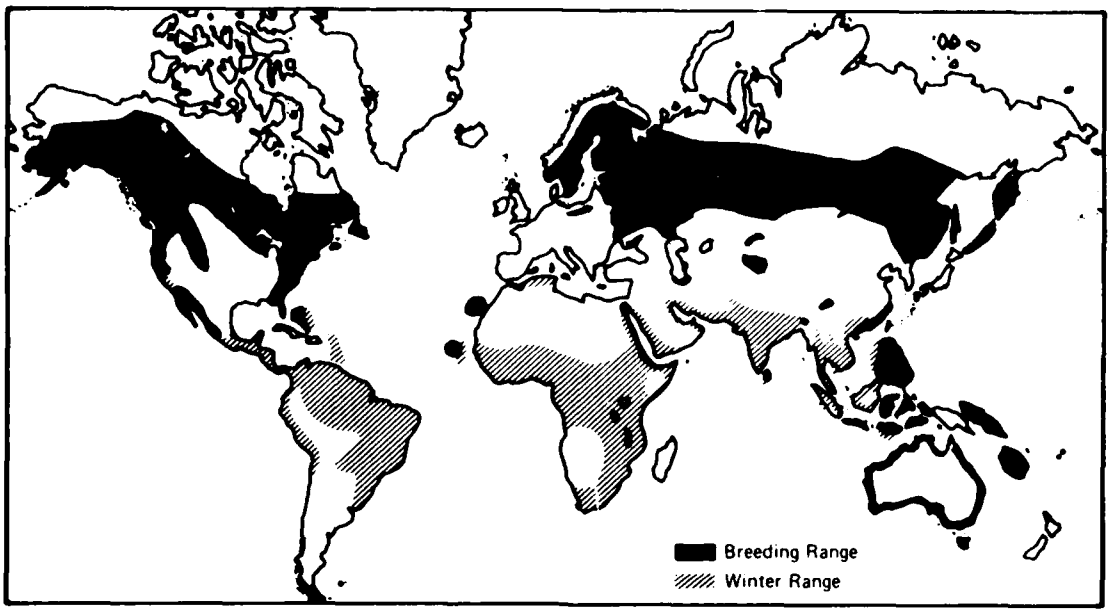

Figure 1. Generalized distribution of the osprey (*Pandion haliaetus*) (map provided by U.S. Army Engineer District, Walla Walla)

Palearctic, North American, Bahaman, and Australasian ospreys. Although only *P. h. carolinensis* is recognized in the United States, Ogden (1977) postulates that birds nesting in southern Florida are more similar to *P. h. ridgwayi*.

STATUS

The osprey is not a Federally listed Threatened or Endangered Species but is listed by the U.S. Fish and Wildlife Service as a national species of "Special Emphasis" (Jantzen 1982). Pesticides severely impacted populations along the North Atlantic coast and Great Lakes, but they are now recovering. Although productivity is generally believed adequate for maintaining regional breeding populations, current numbers remain below historic levels in portions of its range. The osprey is also identified as a sensitive species in 15 states (Table 1) and is protected under the Migratory Bird Treaty Act (16 U.S.C. 703.711). The osprey ranked twelfth in vulnerability among U.S. birds of prey in a recent analysis (LeFranc and Millsap 1984) but ranked third in ongoing management projects, surpassed only by the bald eagle (*Haliaeetus leucocephalus*) and peregrine falcon (*Falco peregrinus*).

Table 1. States where ospreys receive special status. Lists from some states represent legislative authority; others are only advisory. Status is not listed because definitions of categories vary from state to state (data compiled by Office of Migratory Bird Management, U.S. Fish and Wildlife Service, 1980)

State	Authority
Alabama	Alabama Department of Conservation and Natural Resources
Arizona	Arizona Game and Fish Department
California	California Department of Fish and Game
Florida	Florida Game and Fresh Water Fish Commission
Illinois	Illinois Department of Conservation
Kentucky	Endangered Species Committee, Kentucky Academy of Science, and the Kentucky Nature Preserves Commission
Michigan	Michigan Department of Natural Resources
Missouri	Missouri Department of Conservation
New Hampshire	New Hampshire Fish and Game Department
New Jersey	New Jersey Department of Environmental Protection
New Mexico	New Mexico Department of Game and Fish
New York	New York Department of Environmental Conservation
Pennsylvania	Committee on Pennsylvania Birds of Special Concern
Texas	Texas Organization for Endangered Species
Wisconsin	Wisconsin Department of Natural Resources

The present nesting population in the contiguous United States is estimated at about 8000 pairs (Henny 1983). Nesting ospreys are almost invariably associated with aquatic habitats, such as rivers, lakes, estuaries, sea coasts, and more recently, reservoirs. The species is most common in certain marine localities. During recent years in the Northwest, especially in interior regions, reservoirs were responsible for a range expansion, and perhaps a population increase. Although the breeding range in the United States is restricted, ospreys are reported from all states during fall and spring migrations.

The osprey is widely recognized as an indicator of environmental contamination, primarily of organochlorine pesticides. Environmental contaminant research has led to a better understanding of the osprey in general and its relationships with the environment. Since there is now strong population data

for most regions, the osprey should continue its role as a barometer of the environment. Furthermore, the baseline data already collected may play a role in evaluating future perturbations such as acid rain.

CHARACTERS AND MEASUREMENTS

Description

The osprey is intermediate in size between large buteonine hawks and eagles. Both sexes are brownish-black above and white underneath, with brownish-black wristmarks and buff to brown speckles on the breast (Fig. 2). The head is white with a thick, brownish-black stripe through the eye. The undersurface of the tail is white with narrow dark barring. The cere (basal covering of the upper mandible) and feet are blue-gray. In flight it can often be distinguished by the dark wristmarks and the definite crook in the wings. Wing-beats are rather loose and shallow; a series of beats is interspersed with long glides.

Means of standard measurements for adults, given below, show that the female is larger than the male (Prevost 1983, MacNamara 1977):

Character	Male ± SD (N)	Female ± SD (N)
Wing, flattened (mm)	485 ± 12 (49)	507 ± 10 (47)
Culmen, to base of cere (mm)	32.5 ± 1.2 (49)	34.6 ± 1.3 (47)
Tail length, to uropygium (mm)	212 ± 8 (49)	228 ± 6 (47)
Body weight (g)	1437 ± 100 (7)	1798 ± 96 (10)

Ospreys have a number of morphological adaptations associated with their method of hunting: the legs and feet are relatively large and very strong; claws are long, strong, and curved; the undersurfaces of the toes are covered with short spicules; the outer toe is reversible; and the plumage is closely imbricated, dense, compact, and oily (Cramp 1980). These characteristics allow the species to dive into water for fish, which is unique among birds of prey. In contrast, the bald eagle snatches fish from the surface but does not enter the water.

Sex Determination

The sex of adult ospreys can usually be determined in the field by the lack of (or reduced) streaking on the breast of males, the lower pitched calls

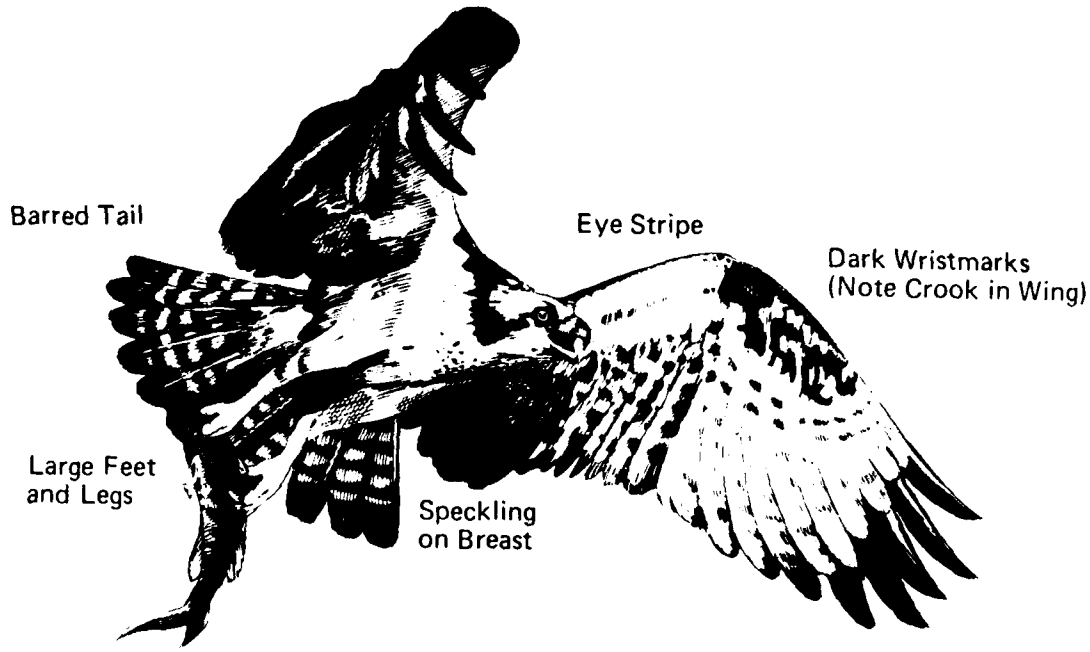

Figure 2. Osprey in flight, showing diagnostic field characters discussed in text

of females (Ogden 1977), and differences in behavior at active nests. For captured adults, MacNamara (1977) suggested measuring tail length (from the uropygial gland to the tip of the longest tail feather). The mean tail length for birds captured by MacNamara in the Northeast was 205 mm (range 200 to 210 mm) for males and 225 mm (range 220 to 233 mm) for females, with no overlap; however, a larger series of data presented by Prevost (1983) suggests some overlap between the sexes.

Age Determination

Juveniles are similar to adults, but the upper parts appear more prominently streaked and the primaries and secondaries are buffier at the tips. The adult plumage is acquired by a gradual molt completed at about 18 months (Brown and Amadon 1968).

POPULATION ATTRIBUTES

Breeding Biology

Courtship and incubation. Migrant ospreys arrive on the breeding grounds from late March (northern California, Garber [1972]) to mid-April (Nova Scotia, Prevost et al. [1978]). Repair of old nests and construction of new nests begins within a few days of arrival. Copulatory behavior was observed as early as April 23 in Nova Scotia and each year continued throughout the egg-laying period (Prevost et al. 1978).

Egg laying typically begins shortly after ice has melted on inland lakes in the northern United States and Canada. However, ospreys were observed in incubation position on May 15 at a frozen high mountain lake in California (Henny 1977a). Minimizing the time spent in courtship might be particularly critical in areas with climatic extremes; the preincubation phase at Eagle Lake (high-elevation California lake) was about 13 days shorter than in climatically moderate coastal Humboldt County (Levenson 1979). Egg laying was early in a nonmigratory population in Florida and ranged from late November to early March, with the peak occurring in December and January (Ogden 1977).

The egg-laying interval in wild birds was reported as 1 to 3 days in Europe (Siewert 1941) and 2 to 3 days in North America (Poole 1982). During a 5-year study in Chesapeake Bay, average clutch size ranged from 2.8 to 3.0, based on 513 nests with eggs (Reese 1977). Incubation, performed primarily by the female (about 75%), lasts about 38 days (Garber and Koplin 1972, Stinson et al. 1976, Levenson 1979) and begins with the laying of the first egg, with subsequent asynchronous hatching (Garber and Koplin 1972, Green 1976). Spitzer (1978) indicated that osprey eggs must be kept at 29-36° C to remain viable, and Van Daele and Van Daele (1982) reported that ospreys at successful nests incubated for 99.5% to 100% of daylight hours.

Young ospreys fledge at 44 to 59 days of age (Stotts and Henny 1975, Stinson 1977), but young do not always grow at the same rate (Poole 1981). In Virginia, Stinson (1977) found the young to be dependent on their parents for at least 6 weeks after fledging, but this may be considerably shorter at higher altitudes and more northern latitudes (Beebe 1974, Henny 1977a).

Sexual maturity. The age when ospreys first breed was reported as 3 years in North America (Henny and Wight 1969), as had been earlier reported in Sweden (Osterlof 1951). Nesting studies examined by Henny and Van Velzen

(1972) suggested that about 6% of relatively stable populations consisted of nonbreeders (birds associated with nests but not laying eggs or exhibiting brooding behavior), which was in close agreement with the 5% to 10% of the population on northern breeding grounds that should be 2-year-olds. However, based on field observations of 20 banded birds in a depleted population with pesticide problems, Spitzer (1980) estimated the proportions of first-time breeders at 50% 3-year-olds, 30% 4-year-olds, and 20% 5-year-olds. Also, Reese (1977) reported paired birds with nests in his population that did not lay eggs and questioned if they were all 2-year-olds. It is still not definitely known if 2-year-old birds (or what percentage thereof) associate with nests. In summary, most nesting studies show a small percentage of birds associated with nests but not laying eggs; the age composition of this segment remains in question.

Reproductive success. Henny (1977b) reviewed productivity (number of young fledged per occupied nest) for numerous locations in the United States and Canada. For a few locations with intensive studies, the number of young fledged per active nest (only those in which eggs have been laid) was also recorded. Based on a mathematical model (using mortality rate estimates from banding data), Henny and Wight (1969) estimated that 0.95 to 1.30 young per breeding age pair must attain flight annually to maintain a stable population (assuming all birds 3 years and older attempted to breed). A combination of slightly lower mortality rates (e.g., band-loss could account for a high bias in Henny and Wight's original estimate) and some birds delaying first breeding until later in life could also yield a stable population with the same production requirement. Observed production rates in most stable populations were within the range established by Henny and Wight.

Calculations by Spitzer et al. (1983), based on rates of population change and observed production of the population between New York City and Boston, suggested that 0.80 young fledged per active nest stabilized the osprey population under the conditions during their study: reduced density (about 10%-15% of pre-DDT era numbers) and a (presumed) age structure skewed toward older birds. Reese (1977) conducted an intensive 5-year nesting study in Chesapeake Bay and determined that 1.14 young were fledged per occupied accessible nest.

Postupalsky (1977a) proposed that osprey production should be based on occupied nests (see definitions in Appendix A) rather than active nests as

initially proposed by Henny and Van Velzen (1972). Both Reese (1977) and Henny (1977b) concluded that, until pairs without eggs can be correctly defined and their significance to the breeding population determined, researchers should include them in published materials so others can calculate productivity with or without nonlaying pairs. Generally, the production rates are similar when either including or excluding the small segment of nonlaying pairs (see Henny 1977b).

Nest disturbance. Ospreys are adaptable and nest successfully under many circumstances. Ospreys have nested successfully on Chesapeake Bay channel markers with constant boat traffic nearby (C. J. Henny, pers. obs). However, Swenson (1979a) showed that an abrupt increase in human boat and foot traffic around nests at the midpoint of incubation in wilderness areas significantly lowered nesting success compared with undisturbed nests. Swenson's study of wilderness ospreys subjected to sporadic but intense disturbance provides an interesting contrast to the "suburban" nests where disturbance was constant. Van Daele and Van Daele (1982) reported that ospreys nesting near humans eventually tolerated their activities whereas those nesting farther from humans were less tolerant. Thus, sporadic disturbances during critical periods of incubation and early nestling stages may be fatal to embryos and nestlings.

Research disturbance was investigated by Poole (1981), who concluded that careful, short-term visits have a negligible impact on osprey reproduction. However, he recommended that researchers climb only nest trees in areas free of mammalian predators or where metal predator guards have been placed around the nest tree. The raccoon (*Procyon lotor*) was of primary concern because it sometimes follows human scent up nest trees and destroys the nests.

Management suggestions for the protection of nests range from merely leaving the nest tree unmolested (Melo 1975) to not cutting within 100 to 150 m (110 to 164 yd) of a nest during nonnesting periods and no closer than 400 m (438 yd) to an active nest (Lind 1976); others recommended intermediate distances (Stone and Reynolds 1977, Adams and Scott 1979). The phenomenon of habituation apparently has led to the varying opinions on tolerance of ospreys to man and his activities.

Migration

Ospreys from most regions of the United States are migratory. However, birds nesting in southern Florida are resident (nonmigratory) (Ogden 1977). Wintering grounds for various North American populations include South and Central America, the West Indies, and perhaps southern Mexico (Worth 1936, Gillespie 1960, Henny and Van Velzen 1972, Melquist et al. 1978). There appears to be little overlap in wintering areas between western birds and those from the Great Lakes and Atlantic coast.

The fall migration occurs generally from late August through November with peak periods in September. Kennedy (1973) indicated that juveniles from Maryland and Virginia remained within 160 km (100 miles) of the nesting site until the last week of August and then began to migrate south; by September 15 most had left the United States. Ospreys from more northern states begin migrating about 1 to 2 weeks later; young ospreys from Nova Scotia begin migration in middle to late September (Prevost et al. 1978).

The return migration of various age classes was described by Henny and Van Velzen (1972) as follows: (1) 1-year-olds do not return to the United States; (2) an estimated 28% to 55% of the 2-year-olds return to their natal vicinity (states where they were hatched or adjacent states), which would represent 5% to 10% of a stable population on the northern breeding ground; and (3) nearly all of the 3-year-old and older birds return to the breeding grounds. Many of the nonbreeding 2-year-olds summer south of their natal area; e.g., some birds produced along the North Atlantic coast are found inland in southeastern states.

Dispersal of Young

Data available on dispersal indicate a low potential for ospreys to pioneer suitable habitat beyond 125 km (78 miles) of nesting concentrations. A review of 32 North American band recoveries of sexually mature birds (Henny 1977b) showed that 22 (69%) were recovered within 30 km (19 miles) of their hatching place, and 8 (25%) were recovered from 30 to 125 km (19 to 78 miles) away; the remaining 2 (6%) were recovered at 150 km (93 miles) and 350 km (217 miles). Spitzer et al. (1983) showed that males did not move beyond 37 km (23 miles) but that 10.3% of the females moved beyond 200 km (124 miles). Greenwood (1980) reviewed dispersal among birds and reported that females usually disperse more than males.

If breeding ospreys are present in the vicinity (banding data suggest within about 125 km [78 miles]), there is a good chance that they will pioneer suitable habitat created by man, especially at reservoirs (Henny 1977b). For additional information, see the section entitled Habitat Requirements. Thus, one must be cautious about annually comparing numbers of nesting pairs in small localized study areas; an apparent loss of birds may merely represent the dispersal phenomenon.

Mortality

Henny and Wight (1969) estimated an annual adult mortality rate of 16.2% to 19.6% using band recovery data; however, first-year mortality was much higher (51.5% to 57.3%). Spitzer (1980) estimated a first-year mortality rate of 41% and an adult mortality rate of 15% for a depleted population with a skewed age distribution; increased postfledging survival seems likely to have occurred in this depleted population, although the estimates by Henny and Wight (1969) may be slightly high. Clapp et al. (1982) listed the oldest osprey record for a wild bird at 21 years and 11 months (a retrapped bird that was still alive). However, Spitzer (1980) recorded a 25-year-old male that was recaptured alive at Gardiner's Island, New York.

Present knowledge of postfledging mortality factors on osprey populations is limited. Carcasses encountered by humans most likely represent a biased sample. However, when 33 ospreys found dead or moribund in the eastern United States between 1964 and 1973 were necropsied (Wiemeyer et al. 1980), major causes of mortality were impact injuries, emaciation, gunshots, and respiratory infections. Of special interest were 2 birds with malignant tumors and 1 with steatitis. High levels of arsenic, mercury, and dieldrin may have contributed to the deaths of at least 3 of these birds. Wiemeyer et al. (1980) also reviewed causes of osprey mortality from published sources and found them to include gunshots, steel traps, impact or electrocution by high-tension wires, being caught or drowned in nets, impact injuries, perforated duodenal ulcer, and secondary air saculitis.

Impact of Pollutants

Organochlorine pesticide residues (primarily DDE) have been correlated with eggshell thinning, poor reproduction, and severe population declines in several osprey populations. Lincer (1975) pointed out that not one North American raptor population exhibiting 18% or more eggshell thinning has been

able to maintain a stable self-perpetuating population. The author's review of the limited osprey data (Johnson et al. 1975, Wiemeyer et al. 1975, Spitzer et al. 1978, Wiemeyer et al. 1978) suggests that residues above 10 ppm DDE (wet weight) in eggs greatly reduce production, but even lower levels may cause losses. These values must be considered preliminary. The effects of other contaminants are even less understood. The egg sensitivity to DDE (and other pesticides) varies among species; thus, critical levels must be determined separately for each species of concern.

Evidence of pesticide residue contamination in ospreys exists primarily from the North Atlantic coast populations, but extremely low reproduction was also reported from the Great Lakes region. Some populations in other areas may have been affected to a lesser degree (e.g., Reese [1975], Johnson et al. [1975]). Anderson and Hickey (1972) reported that osprey eggs collected in Connecticut, New Jersey, and Maryland in 1957 had shells 18% to 21% thinner than museum eggs collected before 1947 (the pre-DDT era). In the late 1960's, eggs from Connecticut had shells 15% to 18% thinner than pre-1947 samples; Maryland eggs showed only 10% to 12% thinning, thus showing some improvement over the 1957 samples. Improved osprey production in seriously affected regions during recent years has paralleled the decline in use of DDT and other persistent chemicals (see reviews, Henny 1977b, Spitzer et al. 1978).

DISTRIBUTION AND ABUNDANCE

The present distribution of nesting pairs (Fig. 3), based on surveys between 1973 and 1981, was summarized by Henny (1983). Nesting ospreys in the contiguous United States now number about 8000 pairs and were divided into regional populations for ease of presentation: (1) the Pacific Northwest, (2) the Western Interior, (3) the Great Lakes, (4) the Atlantic Coast, and (5) Florida and the Gulf Coast. Only fragmentary data were available from Alaska (Hughes 1982); therefore, the state was excluded from this report. For purposes of this review, nesting pairs may include some pairs that constructed or repaired a nest but did not lay eggs. When terminology deviates from this criterion, special mention is made in the text.

Pacific Northwest

Historically, ospreys have nested along the Pacific coast from Washington to southern California, including the Channel Islands. The population is now

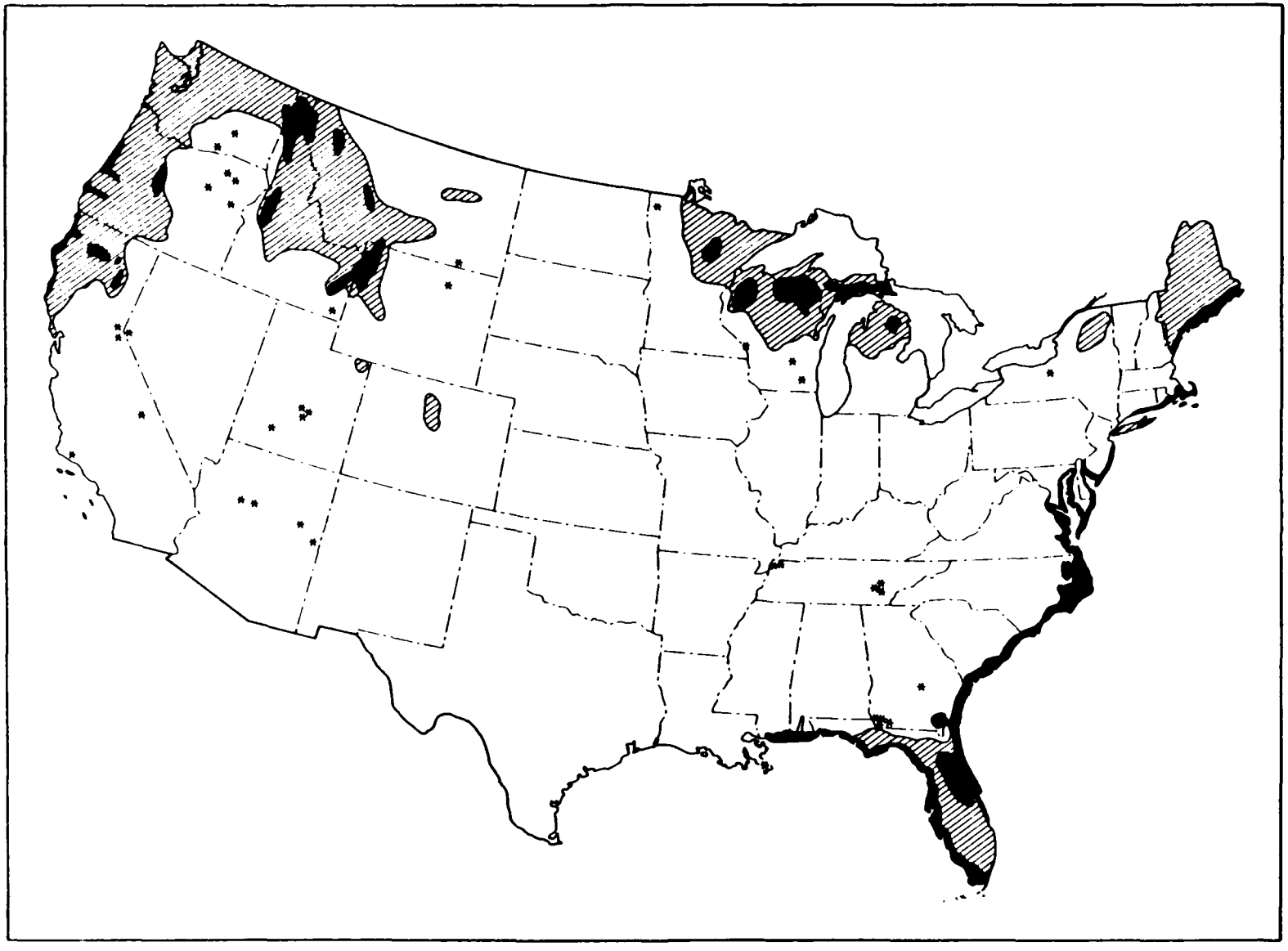

Figure 3. The known distribution of nesting ospreys in the United States (Henny 1983). Cross-hatched area = nesting range, solid area = nesting concentrations, and asterisks = disjunct individual nesting pairs)

primarily restricted to the Pacific Northwest. About 844 pairs (minimum) nest in the forested regions of northern California, Oregon, and Washington, with 1 pair in Nevada (Table 2); this excludes 53 pairs nesting in the eastern portion of Washington which are grouped with the Western Interior population. In California, 20% nest near reservoirs (Henny et al. 1978b), whereas 47% nest near reservoirs in Oregon (Henny et al. 1978a). The use of reservoirs by ospreys increases inland; coastal birds primarily nest along rivers and bays.

The 2 nests reported in central and southern California in 1975 (Henny et al. 1978b) may be either remnants of the larger population that historically nested in the region or recent pioneers from elsewhere. Diamond (1969) noted that the species disappeared from the Channel Islands between 1917 and 1968 and declined to virtual extinction on the mainland of central and southern California during the same period. Likewise, populations on the northernmost islands of adjacent northwestern Mexico were eliminated early in the century and have not returned, although an estimated 810 pairs (minimum) nested farther south in Baja California and the Gulf of California in 1977 (Henny and Anderson 1979).

Western Interior

The northern Rocky Mountains are the focus for a Western Interior population of ospreys that numbers 632 pairs (minimum). Large numbers nest in northern Idaho, western Montana, and the vicinity of Yellowstone and Grand Teton National Parks. This population seems to be extending its range in all directions--probably due to the creation of reservoirs. The importance of reservoirs at the periphery of the present breeding range can be illustrated by the following records: (1) in Idaho, the extreme southwestern nesting concentrations were found at reservoirs; (2) in Arizona, 3 of 4 pairs were at reservoirs; (3) in Utah, 9 of 12 pairs were at reservoirs; (4) in Colorado, 5 of 9 pairs were at reservoirs; and (5) in Wyoming, the easternmost pair was at a reservoir. Swenson (1981) discussed nesting ospreys in eastern Montana (12 pairs) and noted that all were at reservoirs. He concluded that the paucity of early records by naturalists and the present lack of ospreys nesting along rivers strongly suggest that the species did not nest in southeastern Montana before the construction of reservoirs. In adjacent North Dakota, Stewart (1975) reported only 3 known nesting localities for ospreys; all were reservoirs and all were recorded after 1951.

Table 2. Abundance of nesting pairs of ospreys in the United States (from Henny 1983)

State (Year[s]) Surveyed	Nesting Pairs[a]	State (Year[s]) Surveyed	Nesting Pairs[a]	State (Year[s]) Surveyed	Nesting Pairs[a]
Alabama (1981)	2	Maine (1981)	ca 1000	Ohio (1981)	0
Arizona (1981)	4	Maryland (1973-75)[b]	847***	Oklahoma (1981)	0
Arkansas (1981)	0	Massachusetts (1980)	32***	Oregon (1976)	308***
California (1975)	359***	Michigan (1981)	123***	Pennsylvania (1981)	0 (1961)
Colorado (1981)	9	Minnesota (1981)	ca 280	Rhode Island (1981)	19***
Connecticut (1981)	25***	Mississippi (1981)	ca 40	South Carolina(1979)	151*
Delaware (1981)	56***	Missouri (1981)	0 (1969)	South Dakota (1981)	0 (1883)
Florida (1981)	ca 1500-2000	Montana (1974-81)[b]	149**	Tennessee (1981)	5
Georgia (1980)	95***	Nebraska (1981)	0 (1904)	Texas (1981)	0 (1974)
Idaho (1974-80)[b]	323***	Nevada (1981)	1	Utah (1981)	12
Illinois (1981)	0 (1952)	New Hampshire (1981)	6-9	Vermont (1981)	0 (1975)
Indiana (1981)	0 (1960)	New Jersey (1981)	87***	Virginia (1973-75)[b]	722***
Iowa (1981)	0 (1892)	New Mexico (1981)	0 (1920)	Washington (--)[c]	229
Kansas (1981)	0	New York (1981)	120***	West Virginia (1981)	0 (1975)
Kentucky (1981)	0 (1949)	North Carolina (1974)	450***	Wisconsin (1981)	176***
Louisiana (1981)	1	North Dakota (1981)	0 (1973)	Wyoming (1974-81)[b]	82**

[a]Degree of completeness of survey: *** = >90%, ** = >75-90%, * = 60-75%, no asterisk = unsure of completeness. Assuming that nesting surveys average about 90% complete, a total of approximately 8000 pairs is estimated. States with no ospreys now nesting, year ( ) is the last nesting record for state.

[b]Portions of State surveyed in different years.

[c]Reports for several years (no intensive survey).

Great Lakes

The Great Lakes population of 579 pairs (minimum) nests in north-central and northeastern Minnesota and in the northern portions of Michigan and Wisconsin. Today's distribution of nests in Michigan is similar to that reported in 1963-71 (Postupalsky 1977b); however, the clusters are larger, additional scattered nests exist between the clusters, and some range expansion has occurred. The number of known occupied nests in Michigan increased from 75 (40 Upper and 35 Lower Peninsula) in 1971 to 123 (76 Upper and 47 Lower Peninsula) in 1981. Much of the reported increase is probably real, since annual surveys were conducted in Michigan since the early 1960's and the population showed a consistent pattern of improved productivity from the mid-1960's to the mid-1970's (Henny 1977b). Similarly, in Wisconsin, the number of occupied nests increased from 123 in 1977 to 176 in 1981. The number of young fledged per pair ranged from 1.0 to 1.3 during the interval 1977-81, which is considerably greater than the 0.39 to 0.71 reported during the 1960's (Henny 1977b). Survey coverage in Minnesota was not as complete as in Michigan or Wisconsin, although a long series of data was available from the Chippewa National Forest (e.g., Mathisen 1973).

Atlantic Coast

Atlantic coast ospreys nest primarily along bays and estuaries from Maine to Florida (Florida is included with the Gulf coast population). The 2 major focuses for the 3613 nesting pairs in the region are (1) Chesapeake Bay and the adjacent portions of coastal Maryland and Virginia (1569 pairs), and (2) Maine, with an estimated 1000 pairs based on an incomplete inventory (85% estimated along the coast).

The population nesting between New York City and Boston (Spitzer et al. 1983) and in coastal New Jersey (Henny et al. 1977) is a small fraction of its former abundance. Around 1940, the nesting population from New York City to Boston numbered about 1000 pairs, but it had been reduced to about 150 pairs by 1969 and further reduced to 109 by 1975 (Spitzer et al. 1983). Improved production in recent years, associated with reduced DDE residues in eggs (Spitzer et al. 1978), resulted in a population increase by 1981 to 168 active nests (those with eggs laid). Likewise, the New Jersey population increased from 68 pairs in 1975 (Henny et al. 1977) to 87 pairs in 1981.

Recent population estimates for the Chesapeake Bay area were not available, although production rates by the mid-1970's (Henny 1977b), with a few local exceptions, appeared to be normal or nearly normal.

Florida and the Gulf Coast

Most of the osprey population in the Florida and Gulf coast region nests in Florida (an estimated 1500-2000 pairs minimum). A distinct concentration exists through the center of the state from St. John's River south to Lake Okeechobee. Ospreys also nest on the east and west coasts, with another concentration at Florida Bay and the 10,000 Islands area. Kushlan and Bass (1983) reported a population increase in Florida Bay from 1968 to 1973, followed by a decline by 1978 which appears to be continuing. They believe reduced food availability in Florida Bay may be responsible for the population decline. The nesting population along the remainder of the Gulf coast is low (Alabama, 2; Mississippi, ca 40; and Louisiana, 1).

HABITAT REQUIREMENTS

Habitat Components

The majority of osprey populations in the United States are associated with the marine environment, but inland nesting along large rivers, lakes, and reservoirs is also important. The nesting density ranges from solitary pairs to semicolonial situations, as at Orton Pond in North Carolina (Henny and Noltemeier 1975) and Crane Prairie in Oregon (Henny et al. 1978a).

Historically, most ospreys nested in the tops of snags or trees with dead tops, although live trees were also used. With the reduced availability of trees for nesting, especially along the mid-Atlantic coast, ospreys have adjusted by nesting on channel markers, duck blinds, and other man-made platforms, including some built especially for them. In Chesapeake Bay in 1973, only one-third of the nesting ospreys were using trees (Henny et al. 1974). The adjustment to local nest site availability was especially noticeable in Mexico where ospreys nested on cactus in flat terrain with no trees, on rock cliffs and pinnacles, on the ground on small islands in lagoons, and on power poles, masts of sunken ships, and other man-made structures when nothing else was available (Henny and Anderson 1979).

Reservoirs in portions of the range have become increasingly important to nesting ospreys. The criteria that make reservoirs especially suitable were

probably best evaluated at Cascade Reservoir in Idaho (Van Daele and Van Daele 1982). The reservoir was created in 1948 and by 1978 supported about 50 nesting pairs. It was large (surface area 11,452 ha [28,298 acres]), shallow (mean depth at high water 7.6 m [24.9 ft]), and contained an abundance of warmwater fishes, including yellow perch (*Perca flavescens*), northern squawfish (*Ptychocheilus oregonensis*), largescale sucker (*Catostomus macrocheilus*), and brown bullhead (*Ictalurus nebulosus*). Smaller populations of salmonids, including rainbow trout (*Salmo gairdneri*) and mountain whitefish (*Prosopium williamsoni*), were also present. When water levels in the reservoir were raised for irrigation, trees were killed near the shoreline. These snags and those on steep hillsides provided ospreys with nest sites, although some live conifers and man-made structures were used. All osprey nests had a relatively unobstructed view of their surroundings, and all had at least one nearby perch where the male rested. It was noted that nests farther than approximately 1500 m (1635 yd) from human activities were significantly more productive than those nests closer, yet the birds frequently nested close to humans.

Food Habits

Diet. Ospreys feed almost exclusively on live fish, but dead fish are occasionally taken (Dunstan 1974, Nesbitt 1974). A list of the fish captured by ospreys at selected locations and their relative importance in the diet is provided as Table 3. Scattered reports of other prey (although a minute percentage of the biomass intake) have been summarized by Wiley and Lohrer (1973), and the list is indeed diverse: mammals; birds; reptiles including turtles, snakes, and an alligator; amphibians (frogs); and invertebrates including crustaceans, sea snails, and beetles.

Daily food consumption was reviewed by Cramp (1980) and summarized as ranging from 200 to 400 g (0.4 to 0.9 lb), but with wide variations. Visual estimates based on returns to nest sites varied from 300 to 800 g (0.7 to 1.8 lb). Theoretical estimates based on energetics models by different methods ranged from 227 to 286 g (0.5 to 0.6 lb). The number of fish eaten per day (1 to 4) depends on size. Fish in the 11- to 30-cm (4.3- to 11.8-in.) range constituted the bulk of the diet (89%) in a study in Idaho (Van Daele and Van Daele 1982). A long-term study showed that a male brought back an average of 2.2 (range 0 to 4) fish per day during the incubation period, and 4.6 (2 to 11) during the nestling period (Cramp 1980). Nordbakke (1980)

Table 3. Summary of the results of 13 studies of osprey prey species (from Swenson 1979b)

Area	Major Prey Species*	Percentage of Diet
Newnans Lake, Fla.	Gizzard shad (*Dorosoma cepedianum*) Threadfin shad (*D. petenense*)	73
	Sunfish (*Lepomis* sp.) Black crappie (*Pomoxis nigromaculatus*) Large-mouth bass (*Micropterus salmoides*)	15
	Unidentified	12
Mouth of Usal Creek, Calif.	Surf smelt (*Hypomesus pretiosus*)** Night smelt (*Spirinchus starksi*)**	98
Antigonish Harbour, Nova Scotia	Winter flounder (*Pseudopleuronectus americanus*)	90+
Flathead Lake, Mont.	Largescale sucker	59
	Whitefish (*Prosopium* sp.)	26
	Unidentified	11
Humboldt Bay, Calif.	Surfperch (Embiotocidae)	64
	Unidentified	27
Crane Prairie Reservoir, Oreg.	Salmonidae	57
	Tui chub (*Siphateles bicolor*)	43
Eagle Lake, Calif.	Tui chub	48
	Rainbow trout	34
	Tahoe sucker (*Catostomus tahoensis*)	18
Yellowstone River, Wyo.	Cutthroat trout (*Salmo clarki*)	90
	Longnose sucker (*Catostomus catostomus*)	10
Yellowstone Lake, Wyo.	Cutthroat trout	88
	Longnose sucker	7
	Unidentified	5
Lake George, Fla.	Mullet (*Mullus barbatus*)	52
	Crappie (*Pomoxis* sp.)	48
Iddefjord, Norway	Orfe (*Leuciscus idus*)	32
	Northern pike (*Esox lucius*)	25
	Perch (*Perca fluviatilis*)	16
	Dace (*Leuciscus leuciscus*)	8
Paynes Prairie, Fla.	Sunfish	95
Seahorse Key, Fla.	Speckled trout (*Cynoscion nebulosus*)	64
	Striped mullet (*Mugil cephalus*)	27
	Sea catfish (*Galeichthys felis*)	8

* Excluding species comprising less than 5%.
** Spawning in very shallow surf.

concluded that an osprey pair raising 2 young will consume about 170 kg (375 lb) of fish during the breeding season.

Feeding behavior. The osprey captures fish by plunging feetfirst into water; the plunge is preceded by a long glide or shallow headlong dive or brief hover (Cramp 1980). Male ospreys, which essentially provide all of the food for the family, spend over one-third of each day perched near their nests and only 25% to 38% of each day foraging (Green 1976, Stinson 1978, Levenson 1979). Poole (1982) reported increased nestling loss coincided with reduced food delivery rates. Starvation was the primary cause of nestling death; mortality was concentrated in third chicks, which hatched an average of 3.9 days later than their broodmates. Sibling aggression accounted for the preferential feeding of older nestmates, but only at colonies where food was limited. In Idaho, productivity changes were noted in relation to changes in water levels (Van Daele and Van Daele 1982). Productivity was highest in 1979, the year of the lowest water levels. Males spent significantly more time away from the nest site and delivered fewer fish during high-water years. Increased productivity corresponding with an increase in prey availability was also suggested in other studies (Koplin et al. 1977, MacCarter and MacCarter 1979).

Swenson (1979b) suggests that ospreys may select dimersal (bottom-dwelling) fish over pelagic species when they are equally available because dimersal species are comparatively easier to capture. Extremely bad weather conditions such as high wind, torrential rain, floods, and fog stop hunting altogether. Either freezing conditions or high water temperatures may restrict foraging activities because of the unavailability of prey near the water surface (Prevost 1977). Dive success (the proportion of observed dives that were successful) of fishing ospreys has been reported by numerous authors. Studies have analyzed various parameters affecting osprey foraging, including tides, weather variables, age of birds, and type of foraging behavior (i.e., hovers or interhovers).

MANAGEMENT

Management Regions

The relationship between current population numbers and historic numbers is of paramount importance in determining regional population goals or objectives. From the practical standpoint of managing or evaluating osprey

populations, the 5 regional populations delineated earlier in this paper could be classified as major management regions. When population segments within the regions have different histories of reproductive performance or changes in abundance, they could be further subdivided into population units for more specific objectives.

Further subdivisions are probably needed only in the Great Lakes and Atlantic Coast Management Regions. Logic exists for grouping Wisconsin and Michigan since both populations had similar reproductive problems in the past. Historically, Minnesota production rates were never as low as either Wisconsin's or Michigan's. The Atlantic Coast Region should probably be divided into 4 population units: (1) Maine and New Hampshire; (2) Boston through New Jersey; (3) Delaware, Maryland, and Virginia (including Chesapeake Bay); and (4) North Carolina, South Carolina, and Georgia. The populations from Boston through New Jersey are greatly depleted from historic numbers, whereas most populations south of New Jersey did not show serious reproductive problems in the 1960's and 1970's. The population in Maine is not totally understood at this time but is apparently large.

Management Practices

Local projects should evaluate nesting osprey needs and potential nesting habitat with an understanding of the biology and ecology of the species, together with a knowledge of the distribution and abundance of breeding pairs in the vicinity. For example, there is no reason to construct nesting platforms for ospreys at a site if no known nesting pairs live within 300 km (186 miles) because the platforms will seldom be used (see earlier section entitled Dispersal of Young).

Management for ospreys in the United States has followed 3 general patterns: (1) the building of nesting platforms, (2) the creation of osprey management areas near nests designed specifically for the species (especially in the West), and (3) the reintroduction or "hacking*" of 6-week-old ospreys to artificial nest sites at locations without breeding ospreys.

Nesting platforms. Man-made nesting sites are a significant benefit to osprey populations where traditional nesting habitat is disappearing.

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* Hacking is a falconry practice whereby young raptors learn to fly and take prey without any parental help; the birds are fed regularly by humans at a specific site until they become self-sufficient.

Numerous studies have reported greater productivity on artificial structures; however, nesting success on artificial structures has not always been higher (Peterson 1969, Postupalsky 1978, Eckstein et al. 1979, Airola and Shubert 1981, Van Daele and Van Daele 1982). At least a portion of the improved production results from a more stable nest support, thus minimizing the chance of blowdowns during severe windstorms. However, strategic location of the structure may also be important. For example, nest structures should not be constructed close to potential human disturbance, such as in areas where the opening of fishing season will subject the birds to a sudden flurry of human activity. Poole (1981) stated that nest structures should be located so as to allow nesting pairs either early habituation to man or minimum exposure to human activity. Nests in wilderness areas should have human activity carefully controlled in their vicinity (see earlier section on nest disturbance).

Nesting platforms constructed in western forests showed 27% occupancy at Crane Prairie Reservoir, Oregon (Henny et al. 1978a), and 32% occupancy at Lake Almanor, California (Airola and Shubert 1981). Platforms had an occupancy rate of 55% in Michigan (Postupalsky 1978) and 58% in Maryland (Reese 1977). The differences in use rates are probably a function of the availability of suitable natural nest sites. For designs and discussion of nesting structures, see Rhodes (1972), Postupalsky and Stackpole (1974), Eckstein et al. (1979), Frier (1980), Yoakum et al. (1980), and Section 5.1.6 of this manual. Optimum nest height depends on the height of the surrounding vegetation. Ospreys seem to require an unobstructed view of their surroundings from the nest, and a high perch nearby for the male appears to be important.

Management areas. The first osprey management area was established cooperatively in 1969 by the Oregon Department of Fish and Wildlife, the Bureau of Reclamation, and the U.S. Forest Service at Crane Prairie Reservoir in the Deschutes National Forest (Roberts 1969). The area contained about one-third of the osprey breeding population in the state of Oregon and was in jeopardy from timber sales, deterioration of natural snags, and pressure to kill the nongame fish population in the lake. Now many National Forests (USFS) in the West, including the Klamath and Lassen in California, have habitat management plans for ospreys in selected areas. The California Department of Fish and Game (CF&G) also has guidelines to protect osprey habitat. Practices emphasized in these plans (Kahl 1971, Gale and Forbis 1974, Stone and Reynolds 1977) are as follows:

(1) Management activities within 40 m (44 yd) of any nest tree should be limited to measures beneficial to maintaining the nest site, and nest trees should not be felled without approval.

(2) During the nesting season (various dates for locations), human activities (timber harvesting, road construction, yarding, etc.) within a 150- to 200-m (164- to 219-yd) buffer zone of a known nest should be modified (USFS) or eliminated (CF&G); the special treatment areas may be increased or reduced in size depending on topography adjacent to the nest tree.

(3) Records should be kept of osprey reproductive success.

(4) All proposed timber sales within the osprey management zone must have the approval of the forest wildlife biologist.

(5) All large snags within the management zone should be considered future nest sites and not be felled (USFS); timber harvesting may be conducted within the nesting territory before and after the critical nesting period, provided a minimum of 4 flat-topped trees or snags, at least 15 m (50 ft) high, are left within 90 m (100 yd) of the nest tree (CF&G).

(6) Osprey habitat needs should be considered in all land exchange or adjustment policies.

(7) Artificial nest platforms should be created where appropriate natural sites are lacking.

(8) Foraging areas near nesting territories should be identified and protected from degradation; chemical control of nongame fish should not be undertaken until a study is completed showing the impact on ospreys.

Reintroductions. The strong fidelity to a nesting area and the small number of long-distance dispersers led the Tennessee Valley Authority, together with the Tennessee Wildlife Resources Agency, to conclude that the best way to establish breeding ospreys on reservoirs in Tennessee was to "hack" 6-week-old ospreys obtained from Chesapeake Bay to artificial nest sites throughout the state. Between 1979 and 1981, 51 ospreys were brought to Tennessee and 44 fledged successfully (Hammer 1982, Hammer and Hatcher 1983). The hacking studies in Tennessee are being followed with interest, especially since only 5 pairs now nest in the State and no other birds nest within a reasonable distance in adjacent states. A smaller scale hacking program is in progress in eastern Pennsylvania where 12 ospreys were hacked in 1980-81 (Schaadt and Rymon 1983); a bird was also hacked in the state of New York. The hacking projects may be considered an extension of the earlier egg and nestling transfers (Spitzer 1978).

CENSUS AND SAMPLING

The study of osprey populations may be divided into 2 general categories (Henny 1977b): the localized study and the aerial survey. Basic procedures for conducting surveys are described below.

Localized Studies

Intensive ground studies of nesting ospreys have been concentrated along the Atlantic coast, in the Great Lakes States, and on certain large lakes or reservoirs in the western United States. Generally, the studies have been concerned with the arrival time and number of breeding pairs present (occupied nests) and the number of young fledged per nesting pair. Since reproduction was the weak link in the life cycle of the osprey and the first problem noted for declining populations was their poor productivity, the number of young fledged per occupied nest has been a major concern of most localized studies. The researchers have then compared the observed production rates with the standard of 0.95 to 1.30 young per pair (Henny and Wight 1969) to obtain a general idea of the population status on their study area (Henny 1977b). Many of the studies have been conducted for a number of years and show definite reproductive patterns and population trends.

To properly conduct an osprey nesting study, definitions of several terms need to be emphasized. The terms relating to status of nests and breeding territories are defined in Appendix A.

Aerial Censuses

Aerial censuses, using a fixed-winged aircraft or helicopter, are most practical for locating nesting ospreys. Helicopters, although more expensive, are perhaps a more effective means of surveying nesting ospreys in smaller areas such as National Forests or portions of states (Carrier and Melquist 1976). Eggs and nestlings can also be counted much more accurately from a helicopter; in fact, the author's experience indicates that young in nests cannot be counted with accuracy from fixed-wing aircraft. The fixed-wing aerial survey approach, however, can be used to estimate populations over large geographical areas (i.e., states or regions) in a relatively short time.

Another advantage to aerial censusing is the ability to include birds that have pioneered into new habitat, which are difficult to detect in localized studies. Besides the requirement that nests be conspicuous from the air,

the main concern is proper timing. The best time to census ospreys is during the incubation period when the birds are associated with nest sites. Relatively synchronous nesting and a 38-day incubation period occur in northern latitudes, so there can be several weeks when these conditions are met. The lack of nesting synchrony in the more southern latitudes causes difficulties when a single aerial survey is used to determine the number of nesting pairs because some pairs will always be missed (Henny and Anderson 1979).

The most efficient fixed-wing aerial surveys of osprey nesting populations involve both an air count and a simultaneous ground count. This procedure allows an adjustment factor (visibility factor) to be calculated so that the total population, including those not seen from the air, can be accurately estimated. In areas intensively surveyed by helicopters, an independent ground count may not be needed.

Osprey nests are large and usually placed at the top of a tree or man-made structure. During the census, it is important to record (1) the type of nest structure and habitat, (2) the nest location on a map, (3) activity at the nest (see definitions in Appendix A), and (4) the survey area boundaries or route taken. Usually more nests are present than nesting pairs, so nest counts alone are not accurate estimates of population size.

Osprey nests are conspicuous, but not all nests will be seen from the air. The visibility of nests is variable, depending on the nest structure and habitat (Henny et al. 1974, Henny and Anderson 1979). For example, nests on duck blinds are more visible than nests in trees (Henny et al. 1974). Consequently, the proportion of nests that are observed must be determined separately for nests on different structures and in different habitats by conducting a second survey independently of the actual census. The second survey, which may be made aerially, by boat, or from land, need only sample selected areas to determine visibility rates. The second survey must be independent of the first for the procedure to work; i.e., the second crew should not see the maps with nest locations plotted by the first crew. Compare occupied nests recorded during both surveys and estimate the total numbers of nests in each structure-habitat category by the following formula (from Henny et al. 1974):

$$\hat{N} = \frac{n_1 n_2}{m}$$

where

$\hat{N}$ = estimate of the number of nests

n_1 = number of nests observed during the first survey

n_2 = number of nests observed during the second survey

m = number of individual nests observed by both surveys

Thus, $\hat{N}/n_1$ becomes the estimation of the aerial visibility rate. If the second survey is conducted on only portions of the census area, the total number of nests on the entire area can be estimated by multiplying the number of nests counted during the first survey in each nest structure-habitat category by the visibility rates $(\hat{N}/n_1)$ for that category as determined from the area surveyed twice. An estimate of the variance, which is low, is provided in Henny et al. (1974), but a more appropriate unpublished estimate of the variance is available from the author.

LITERATURE CITED

Adams, J. K., and V. E. Scott. 1979. Timber harvest modification around an active osprey nest. West. Birds 10:157-158.

Airola, D. A., and N. Shubert. 1981. Reproductive success, nest site selection and management of ospreys at Lake Almanor, California, 1969-1980. CAL-NEVA Wildl. Trans. 1981:79-85.

Anderson, D. W., and J. J. Hickey. 1972. Eggshell changes in certain North American birds. Proc. Int. Ornithol. Congr. 15:514-540.

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia (vultures, eagles, hawks, and falcons). British Columbia Provincial Mus. Occas. Pap. No. 17. 163 pp.

Brown, L. H., and D. Amadon. 1968. Eagles, Hawks, and Falcons of the World. McGraw-Hill, New York. 2 vols. 945 pp.

Carrier, W. D., and W. E. Melquist. 1976. The use of rotor-winged aircraft in conducting nesting surveys of ospreys in northern Idaho. Raptor Res. 10:77-83.

Clapp, R. B., M. K. Klimkiewicz, and J. H. Kennard. 1982. Longevity records of North American birds: Gaviidae through Alcidae. J. Field Ornithol. 53:81-124.

Cramp, S., chief ed. 1980. Handbook of the Birds of Europe, the Middle East and North Africa. Vol II. Oxford Univ. Press. 695 pp.

Diamond, J. M. 1969. Avifauna equilibria and species turnover rates on the Channel Islands of California. Proc. Nat. Acad. Sci. (U.S.A.) 64:57-63.

Dunstan, T. C. 1974. Feeding activities of ospreys in Minnesota. Wilson Bull. 86:74-76.

Eckstein, R. G., P. V. Vanderschaegen, and F. L. Johnson. 1979. Osprey nesting platforms in north-central Wisconsin. Passenger Pigeon 41: 145-148.

Frier, J. A. 1980. Artificial nest structures for osprey. Trans. Northeast. Sect. Wildl. Soc. 37:194-197.

Gale, R. M., and L. D. Forbis. 1974. A habitat management plan for ospreys on the Klamath National Forest. U.S. For. Serv., San Francisco. 45 pp.

Garber, D. P. 1972. Osprey study, Lassen and Plumas Counties, California, 1970-71. Calif. Dep. Fish and Game Admin. Rep. No. 72-1. 33 pp.

_____, and J. R. Koplin. 1972. Prolonged and bisexual incubation by California ospreys. Condor 74:201-202.

Gillespie, M. 1960. Long distance flyers--the ospreys. EBBA News 23: 55-62.

Green, R. 1976. Breeding behavior of ospreys *Pandion haliaetus* in Scotland. Ibis 118:475-490.

Greenwood, P. J. 1980. Mating systems, philopatry, and dispersal in birds and mammals. Anim. Behav. 28:1140-1162.

Hammer, D. A. 1982. Osprey reintroductions in the Tennessee Valley. Pages 104-106 In R. R. Odum and J. W. Guthrie, eds. Proc. Nongame and Endangered Wildlife Symposium, Athens, Ga.

_____, and R. M. Hatcher. 1983. Restoring osprey populations by hacking preflighted young. Pages 293-297 In D. M. Bird, chief ed. Biology and Management of Bald Eagles and Ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec. 325 pp.

Henny, C. J. 1977a. California ospreys begin incubation at a frozen mountain lake. Bird-Banding 48:274.

_____. 1977b. Research, management, and status of the osprey in North America. Pages 199-222 In R. D. Chancellor, ed. I.C.B.P. World Birds of Prey Conf., Vienna, Austria. 442 pp.

_____. 1983. Distribution and abundance of nesting ospreys in the United States. Pages 175-186 In D. M. Bird, chief ed. Biology and Management of Bald Eagles and Ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec. 325 pp.

_____, and D. W. Anderson. 1979. Osprey distribution, abundance, and status in western North America. III. The Baja California and Gulf of California population. Bull. South. Calif. Acad. Sci. 78:89-106.

_____, and A. P. Noltemeier. 1975. Osprey nesting populations in the coastal Carolinas. Am. Birds 29:1073-1079.

_____, and W. T. Van Velzen. 1972. Migration patterns and wintering localities of American ospreys. J. Wildl. Manage. 36:1133-1141.

_____, and H. M. Wight. 1969. An endangered osprey population: Estimates of mortality and production. Auk 86:188-198.

_____, M. A. Byrd, J. A. Jacobs, P. D. McLain, M. R. Todd, and B. F. Halla. 1977. Mid-Atlantic Coast osprey populations, present numbers, productivity, pollutant contamination, and status. J. Wildl. Manage. 41: 254-265.

_____, J. A. Collins, and W. J. Deibert. 1978a. Osprey distribution, abundance, and status in western North America. II. The Oregon population. Murrelet 59:14-25.

_____, D. J. Dunaway, R. D. Mallette, and J. R. Koplin. 1978b. Osprey distribution, abundance, and status in western North America. I. The northern California population. Northwest Sci. 52:261-271.

_____, M. M. Smith, and V. D. Stotts. 1974. The 1973 distribution and abundance of breeding ospreys in the Chesapeake Bay. Chesapeake Sci. 15:125-133.

Hughes, J. H. 1982. The osprey in southeast Alaska. Pages 197-204 In W. N. Ladd and P. F. Schempf, eds. Proc. Symp. Raptor Management and Biology in Alaska and Western Canada. U.S. Fish and Wildl. Serv., Anchorage, Alaska. 335 pp.

Jantzen, R. A. 1982. Identification of national species of special emphasis. Federal Register 47(176):39890-39891.

Johnson, D. R., W. E. Melquist, and G. J. Schroeder. 1975. DDT and PCB levels in Lake Coeur d'Alene, Idaho, osprey eggs. Bull. Environ. Contam. Toxicol. 13:401-405.

Kahl, J. R. 1971. Osprey habitat management plan, Lassen National Forest. U.S. For. Serv., San Francisco. 38 pp.

Kennedy, R. S. 1973. Notes on the migration of juvenile ospreys from Maryland and Virginia. Bird-Banding 44:180-186.

Koplin, J. R., D. S. MacCarter, D. P. Garber, and D. L. MacCarter. 1977. Food resources and fledgling productivity of California and Montana ospreys. Pages 205-214 In J. C. Ogden, ed. Trans. North Am. Osprey Res. Conf. U.S. Nat. Park Serv., Trans. Proc. Ser. No. 2. 258 pp.

Kushlan, J. A., and O. L. Bass, Jr. 1983. The osprey population in southern Florida. Pages 187-200 In D. M. Bird, chief ed. Biology and Management of Bald Eagles and Ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec. 325 pp.

LeFranc, M. N., Jr., and B. A. Millsap. 1984. A summary of state and federal agency raptor management programs. Wildl. Soc. Bull. 12:274-282.

Levenson, H. 1979. Time and activity budget of ospreys nesting in northern California. Condor 81:364-369.

Lincer, J. L. 1975. DDE-induced eggshell-thinning in the American kestrel: A comparison of the field situation with laboratory results. J. Appl. Ecol. 12:781-793.

Lind, G. S. 1976. Production, nest site selection, and food habits of ospreys on Deschutes National Forest, Oregon. M.S. Thesis, Oreg. State Univ., Corvallis. 53 pp.

MacCarter, D. L., and D. S. MacCarter. 1979. Ten-year nesting status of ospreys at Flathead Lake, Montana. Murrelet 60:42-49.

MacNamara, M. 1977. Sexing the American osprey using secondary sexual characteristics. Pages 43-45 In J. C. Ogden, ed. Trans. North Am. Osprey Res. Conf. U.S. Nat. Park Serv., Trans. Proc. Ser. No. 2. 258 pp.

Mathisen, J. E. 1973. Bald eagle-osprey status report, 1972. Loon 45:15-16.

Melo, J. 1975. Logging around an osprey nest site--an observation. J. For. 73:724-725.

Melquist, W. E., D. R. Johnson, and W. D. Carrier. 1978. Migration patterns of northern Idaho and eastern Washington ospreys. Bird-Banding 49: 234-236.

Nesbitt, S. A. 1974. Foods of the osprey at Newnan's Lake. Fla. Field Nat. 2:45.

Nordbakke, R. 1980. The diet of a population of ospreys *Pandion haliaetus* in south-eastern Norway. Fauna Norv. Ser. C, Cinclus 3:1-8.

Ogden, J. C. 1977. Preliminary report on a study of Florida Bay ospreys. Pages 143-151 In J. C. Ogden, ed. Trans. North Am. Osprey Res. Conf. U.S. Nat. Park Serv., Trans. Proc. Ser. No. 2. 258 pp.

Osterlof, S. 1951. Fiskgjusens, *Pandion haliaetus* (L.), Flyttning. Var Fagelvarld 10:1-15 (in Swedish, English summary).

Peterson, R. T. 1969. Population trends of ospreys in the northeastern United States. Pages 333-337 In J. J. Hickey, ed. Peregrine Falcon Populations. Univ. Wisc. Press, Madison. 596 pp.

Poole, A. 1981. The effects of human disturbance on osprey reproductive success. Colonial Waterbirds 4:20-27.

_____. 1982. Brood reduction in temperate and sub-tropical ospreys. Oecologia (Berl.) 53:111-119.

Postupalsky, S. 1977a. A critical review of problems in calculating osprey reproductive success. Pages 1-11 In J. C. Ogden, ed. Trans. North Am. Osprey Res. Conf. U.S. Nat. Park Serv., Trans. Proc. Ser. No. 2. 258 pp.

_____. 1977b. Status of the osprey in Michigan. Pages 153-165 In J. C. Ogden, ed. Trans. North Am. Osprey Res. Conf. U.S. Nat. Park Serv., Trans. Proc. Ser. No. 2. 258 pp.

_____. 1978. Artificial nesting platforms for ospreys and bald eagles. Pages 35-44 In S. A. Temple, ed. Endangered Birds. Univ. Wisc. Press, Madison. 466 pp.

_____, and S. M. Stackpole. 1974. Artificial nesting platforms for ospreys in Michigan. Raptor Res. Rep. 2:105-117.

Prevost, Y. A. 1977. Feeding ecology of ospreys in Antigonish County, Nova Scotia. M.S. Thesis, MacDonald College of McGill Univ., Montreal, Quebec.

_____. 1983. Osprey distribution and subspecies taxonomy. Pages 157-174 In D. M. Bird, chief ed. Biology and Management of Bald Eagles and Ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec. 325 pp.

_____, R. P. Bancroft, and N. R. Seymour. 1978. Status of the osprey in Antigonish County, Nova Scotia. Can. Field-Nat. 92:294-297.

Reese, J. G. 1975. Osprey nest success in Eastern Bay, Maryland. Chesapeake Sci. 16:56-61.

_____. 1977. Reproductive success of ospreys in central Chesapeake Bay. Auk 94:202-221.

Rhodes, L. I. 1972. Success of osprey nest structures at Martin National Wildlife Refuge. J. Wildl. Manage. 36:1296-1299.

Roberts, H. B. 1969. Management plan for the Crane Prairie Reservoir Osprey Management Area. USDA For. Serv. and Oreg. State Game Comm. 20 pp.

Schaadt, C. P., and L. M. Rymon. 1983. The restoration of ospreys by hacking. Pages 299-305 In D. M. Bird, chief ed. Biology and Management of Bald Eagles and Ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec. 325 pp.

Siewert, H. 1941. Zur Brutbiologie des Fischadlers. J. Orn. (Lpz.) 89: 145-193.

Spitzer, P. R. 1978. Osprey egg and nestling transfers--Their value as ecological experiments and as management procedures. Pages 171-182 In S. A. Temple, ed. Endangered Birds. Univ. Wisc. Press, Madison. 466 pp.

_____. 1980. Dynamics of a discrete coastal breeding population of ospreys (*Pandion haliaetus*) in the northeastern United States during a period of decline and recovery, 1969-1978. Ph. D. Diss., Cornell Univ., Ithaca, New York. 64 pp.

_____, A. F. Poole, and M. Scheibel. 1983. Initial population recovery of breeding ospreys in the region between New York City and Boston. Pages 231-241 In D. M. Bird, chief ed. Biology and Management of Bald Eagles and Ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec. 325 pp.

_____, R. W. Risebrough, W. Walker II, R. Hernandez, A. Poole, D. Puleston, and I. C. T. Nisbet. 1978. Productivity of ospreys in Connecticut-Long Island increases as DDE residues decline. Science 202:333-335.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College Center Environ. Studies. N. Dak. State Univ., Fargo. 295 pp.

Stinson, C. H. 1977. Familial longevity in ospreys. Bird-Banding 48: 72-73.

_____. 1978. The influence of environmental conditions on aspects of the time budgets of breeding ospreys. Oecologia (Berl.) 36:127-139.

_____, M. A. Byrd, and G. Bean. 1976. Osprey incubation temperatures: Studies with a telemetering egg. Raptor Res. 10:90-91.

Stone, T., and F. Reynolds. 1977. Protection of osprey habitat in California. Calif. Dep. Fish and Game Admin. Rep. No. 77-4. 25 pp.

Stotts, V. D., and C. J. Henny. 1975. The age at first flight for young American ospreys. Wilson Bull. 87:277-278.

Swenson, J. E. 1979a. Factors affecting status and reproduction of ospreys in Yellowstone National Park. J. Wildl. Manage. 43:595-601.

_____. 1979b. The relationship between prey species ecology and dive success in ospreys. Auk 96:408-412.

_____. 1981. Status of the osprey in southeastern Montana before and after construction of reservoirs. West. Birds 12:47-51.

Van Daele, L. J., and H. A. Van Daele. 1982. Factors affecting the productivity of ospreys nesting in west-central Idaho. Condor 84: 292-299.

Vaurie, C. 1965. The birds of the palearctic faunas: Non-passeriformes. Witherby, London. 763 pp.

Wiemeyer, S. N., T. G. Lamont, and L. N. Locke. 1980. Residues of environmental pollutants and necropsy data for eastern United States ospreys, 1964-1973. Estuaries 3:155-167.

_____, P. R. Spitzer, W. C. Krantz, T. G. Lamont, and E. Cromartie. 1975. Effects of environmental pollutants on Connecticut and Maryland ospreys. J. Wildl. Manage. 39:124-139.

Wiemeyer, S. N., D. M. Swineford, P. R. Spitzer, and P. D. McLain. 1978. Organochlorine residues in New Jersey osprey eggs. Bull. Environ. Contam. Toxicol. 19:56-63.

Wiley, J. W., and F. E. Lohrer. 1973. Additional records of non-fish prey taken by ospreys. Wilson Bull. 85:468-470.

Worth, C. B. 1936. Summary and analysis of some records of banded ospreys. Bird-Banding 7:156-160.

Yoakum, J., W. P. Dasmann, H. R. Sanderson, C. M. Nixon, and H. S. Crawford. 1980. Wildlife habitat improvement techniques. Pages 329-403 In S. O. Schemnitz, ed. Wildlife Techniques Manual. 4th ed. Wildl. Soc., Washington, D.C. 686 pp.

APPENDIX A

Terms Relating to the Status of Nests and Breeding Territories (from Postupalsky 1977a)

Nest or eyrie. A structure built by birds for breeding purposes.

Breeding territory. For the purposes of osprey population studies, this is defined as an area containing one or more nest structures within the home range of 1 mated pair of birds. Such nests were presumably built by the same pair (or its predecessors) and are typically situated more or less close together and farther from nests of other pairs.

Occupied nest. Any nest at which at least one of the following activity patterns was observed during a given breeding season:

a. Young raised.

b. Eggs laid.

c. One adult observed sitting low in the nest, presumably incubating.

d. Two adults present on or near the nest, regardless of whether or not it had been repaired during the season under consideration, provided there is no reason to suspect that this pair had already been counted elsewhere.

e. A recently repaired nest with fresh sticks (clean breaks), or fresh boughs on top, and/or droppings and/or molted feathers on its rim or underneath. Such evidence is acceptable, especially late in the season in cases where no earlier check was made. Frustration nests (defined below) should be excluded if the original nest is counted, or vice versa.

All of the above observations indicate the known or inferred presence of one mated pair of ospreys associated with a nest. Usually, the author (Postupalsky) does not recognize the following observations as sufficient evidence for an occupied nest:

a. One adult near an empty, unrepaired nest.

b. Two adults seen together during the breeding season with no known nest. Such a pair may be included in a population count, but probably should not be used in calculations of reproductive success unless one has reasons to believe that this pair's nest may have been overlooked.

Occupied breeding territory. Consists of one occupied nest and may also include one or more alternate nests (defined below). Since, by definition, there can be only one occupied nest per occupied territory, these two terms can be used synonymously in censuses of breeding populations and in calculations of reproductive success.

Unoccupied breeding territory. A nest or group of alternate nests at which none of the activity patterns diagnostic of an occupied nest were observed in a given breeding season.

Active nest or active breeding territory. A nest in which eggs have been laid. This category is more restrictive than occupied nest and should be used

only in studies where sufficient early observations have been made to determine for each nest whether or not eggs have been laid. In short, this category excludes nonnesting territorial pairs (called "housekeepers" by some) and subadults (2-year-old ospreys?) which may go through the early motions of nestbuilding and mating without laying eggs. Activity patterns a, b, and in most cases c (listed immediately below the heading Occupied nest) are signs of an active nest.

Productive or successful nest. An occupied nest from which at least one young fledged during the breeding season under consideration; or, if actual fledging was not proven, an occupied nest in which at least one young was raised to an advanced stage of development (i.e., to near fledging age).

Unproductive, unsuccessful nest, or nest failure. An occupied nest from which no young fledged due to any cause:

a. No eggs laid.

b. Eggs destroyed or otherwise lost.

c. Eggs failed to hatch (due to infertility, embryonic death, or abnormal development).

d. Young hatched, but are known to have died prior to fledging.

Alternate nest. One of several nest structures within the breeding territory of one pair of birds, including frustration nests (defined below). Alternate nests may be on adjacent trees or stubs or, in absence of suitable support nearby, as much as a mile or more apart.

Frustration nest. An alternate nest built, repaired, or frequented by a pair of birds subsequent to a nesting failure at another nest during the same breeding season. The habit of building frustration nests is well known in the osprey. After failing to rear young in its original nest, a pair may build a new nest later in the season but, as a rule, will not re-lay in it, this undoubtedly due to the advanced season. The term frustration nest, then, describes a special case of alternate nest. No implication relative to the psychological state of the birds is intended. The following year the ospreys may use the frustration nest or their old nest.

NOTE: Under certain circumstances, ospreys may be seen at more than one nest within their breeding territory during the course of a single breeding season. In addition to the phenomenon of frustration nests described above, a pair may inspect one structure just prior to laying, and then nest in another structure nearby. In such instances only one nest should be considered as occupied. Obviously, it is important to consider this habit if errors due to counting the same pair twice are to be avoided.

This classification of nests and breeding territories has proven useful in extensive osprey population studies in which only brief and infrequent visits are made during each breeding season. It is also applicable to studies of other raptors.

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